An illustrated guide to the state of health of trees

Recognition and interpretation of symptoms and damage

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Preface

Insect pests and diseases routinely affect the health of trees and have an important role in forest dynamics. Occasionally, insect populations grow rapidly to damaging proportions and major disease outbreaks occur. These events can have catastrophic impacts leading to the complete destruction of large areas of natural and/or planted forests, to loss or reduction of vital forest ecosystem functions and to considerable economic losses. In developing countries and countries in transition, severe pest outbreaks may compromise national economics, undermine local livelihoods and threaten food security.

Despite the significant adverse impacts, and indications that outbreaks of forest insect pests and diseases are on the increase, some countries do not have the personnel or infrastructure to identify and carry out forest protection measures. At the same time there is also an increasing awareness of tree health problems linked to non-living or abiotic influences, particularly the perceived effects of atmospheric pollution.

The effective management of all tree health problems depends on their early detection. All investigations should begin with the initial discovery and recognition of symptoms in the field. To improve awareness of tree health and responses to health-related problems, action must be taken to train people who work directly with trees in the recognition and interpretation of symptoms. A broadening of visual skills in the initial assessment of tree health is urgently needed to improve the early detection and timely management of problems.

Sometimes the knowledge that a problem is not serious will suffice and will avoid expensive and unnecessary treatments. Similarly, the recognition that a symptom is of a previously unknown type will help to identify a new problem at an early stage and may prevent significant losses.

This publication aims to help people make visual assessments of tree health problems and to provide a preliminary diagnosis. It is not an identification guide to insect pests and diseases of trees. It will help readers to recognize symptoms of ill health, to distinguish these from normal events that signal a temporary decline, and to improve their skills in making the vital preliminary diagnosis. This is an important and neglected capability that will often be sufficient for formulating a simple plan to contain a disease or insect pest or for deciding alternatively that no action is necessary.

Acknowledgements

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1 Introduction

Understanding tree health

The aim of this guide is to help readers recognize symptoms of ill health in trees and understand their general significance. The guide provides 140 photographs of symptoms from more than 50 tree species to be used as a basis for demonstrating the effects of pest (biotic) and non-living (abiotic) influences on trees. It aims to assist anyone interested in tree health or responsible for managing trees.

Tree health is not always routinely monitored in developing countries, and working guidelines and forest protection measures are not always incorporated into forest management. Many people working with trees do not pay systematic attention to tree health until trees have died and it is too late for intervention. Preliminary diagnoses of problems using this guide will assist in better planning and more effective management of trees.

2 Using the guide

Investigating problems

The general assessment of tree health has always relied on a careful study of symptoms. Since symptoms are often the only evidence available for diagnosis, their recognition and interpretation are the key elements of this guide. It may not always be possible to make a definitive diagnosis or to confirm the precise cause of a problem, but informed observations can provide invaluable information and help in decision-making in the field. This is a major advantage for people who cannot obtain technical assistance or advisory support every time trees become unhealthy. Recognizing a previously unknown type of symptom helps to identify a new problem at an early stage.

A symptom-based approach considers all possible factors that affect tree health. The interpretation of symptoms is discussed in Chapter 6. Guidelines are provided on how to make a preliminary diagnosis, which acts as the basis for further action. The next step may be to do nothing, to seek further help, to remove the tree or to replant with a different tree species. Replanting with a new tree species should always be the last option because of cost and the risk of further damage if the cause of the original problem is still unresolved.

3 What is tree health?

Definitions and descriptions of key terms

"Tree health" as a discipline refers to the study of all factors (biotic and abiotic) that affect the vigour and productivity of a tree, as expressed by different symptoms and types of damage. The health of a tree can be expressed qualitatively by describing the symptoms or damage, or quantitatively through assessments of crown condition.

A few comments are required on the meaning of "pest". FAO defines it as any species, strain or biotype of plant, animal or pathogenic agent injurious to plants or plant products. For this guide, the term "pest" refers to detrimental insects, fungi, animals, weeds, viruses, mites, parasitic plants and phytoplasmas.

In a symptom-based approach to tree health it is useful to have a term that refers to a reduction in tree health without reference to the specific cause. "Ill health" is used increasingly to describe a deviation from the normal, healthy state. It encompasses the effects of disease, insect damage, declines, diebacks and disorders, and other harmful influences that affect the appearance and health of the tree.

Clear definitions assist in providing accurate descriptions of tree health problems. Since reports of "new" diseases often describe symptoms only, it is essential that these be communicated in a comprehensive and accurate manner. It is vital that the terms used to describe the symptoms of a particular problem be clearly understood and consistently applied. The use of scientific names is recommended because they are internationally recognized; common names, on the other hand, may create confusion because they vary from place to place.

Short definitions and descriptions of key terms as used in this book are given in Annex 1. These may differ from other published definitions.

Diseases, damage and disorders

Tree health problems may be divided into diseases caused by pathogens, damage caused by insect pests and other animals, disorders linked to abiotic influences and other miscellaneous problems described in various ways, e.g. declines and diebacks. "Disorder" is not specifically defined, although it is often associated with nutrient imbalances.

4 Why trees become unhealthy

Causes of ill health in trees

The many reasons for the disruption of the healthy growth of a tree can be divided into two main categories: living (biotic) and non-living (abiotic) factors. More than one factor can affect the health of a tree at any time. A useful distinction can be made between primary pests, which first and principally affect the health of the tree, and secondary pests, which have a less important influence and usually affect trees already weakened by a predisposing factor. The impact of insect pests is often increased by a previous weakening of the tree's vigour and a lowering of its natural resistance to infestation, for example through waterlogging or nutrient deficiencies. One of the most common predisposing factors is poor nursery management. Trees that become pot-bound as saplings do not develop a healthy root system and therefore grow poorly when planted.

Stress and off-site factors undoubtedly have a major role in determining the health or condition of trees, as do poor soil and drainage. However, undue emphasis on poor sites or adverse climatic events such as drought and frosts as primary causes of observed symptoms and damage to trees may prevent a more careful search for possible biotic influences.

Pest (biotic) influences

Some pest groups are better known than others simply because they are easier to see. Insects are frequently found on trees although many are casual feeders and not serious pests, and some are beneficial (natural enemies). Fungi are frequently seen on dead and decayed organic matter, but they may not necessarily be the primary cause of the symptoms observed. Most fungi in nature are saprobic (living on dead or decaying tissue) and only a very small proportion are pathogenic. Insects and fungi are relatively easy to distinguish by direct observation, while the remaining pest groups are not. Several other living agents occur on trees, including mosses, lichens and epiphytes such as bromeliads, but these have only a superficial impact on tree health (see Plate 16).

Major groups of pests that occur on trees are described in Table 1 and are illustrated in the colour plates.

Table 1. Major groups of pests that infest trees

PEST	NOTES	CORRESPONDING COLOUR PLATE
Fungi	A living microorganism characterized by a cell wall containing chitin and lacking chlorophyll.[a] Common cause of disease. Associated with a wide range of symptoms. Diverse group of pest organisms: some with large fruiting bodies visible with the naked eye but many only "visible" when grown in an artificial culture in the laboratory. Fungi also play a secondary role in decays and rots.	Rust fungus on *Acacia mangium* [2.2]
Bacteria	A living microorganism characterized by cell membranes and cell walls.[a] Uncommon cause of disease but several species have caused widespread losses in trees. Cannot be detected with the naked eye except *en masse* in bacterial oozes.	Bacterial ooze of *Eucalyptus* sp. [9.5] Bacterial wilt of *Eucalyptus* [9.6]
Viruses	An ultramicroscopic (one dimension less than 200 μm) organism. Viruses cannot reproduce alone (and thus are not living organisms according to some definitions) but must first infect a living cell and take over its synthetic and reproductive facilities.[b] More common cause of symptoms than generally perceived. Symptoms may resemble those of other pests and factors. Transfer to new host plants by (insect) vectors, sometimes by manual transmission.	Leaf discolouration and flecking on *Gliricidia sepium* [10.9]
Phytoplasmas	Extremely small, phloem-limited plant pathogenic bacteria-like prokaryotes that lack a cell wall.[c] Uncommon cause of disease but more widespread than usually thought, mainly because typical symptoms are not recognized.	Gliricidia little leaf disease [8.1 & 8.2]
Insects	Widespread, extremely common cause of damage, and rarely host tree specific (unlike many pathogens). Readily seen but often assumed to be the cause of more damage than is supported by biological evidence. Different insect orders are associated with particular patterns of feeding and breeding on trees.	Leaf miner damage on *Pterocarpus indicus* [13.6]
Mites	Common pests whose feeding results typically in distinct symptoms (e.g. galls); mites are not readily seen with the naked eye.	Leaf galls on *Vangueria infausta* [2.1]
Parasitic plants	Widely present in many tree species that have been weakened by other factors. Rarely the cause of major losses.	Parasitic plant on *Schinus molle* [14.13]
Weeds	Some weeds outcompete trees, especially when young, others grow in the canopy and can strangle trunks and branches.	Bromeliads on cacao [16.1]
Larger animals	Includes large mammals such as elephants, monkeys, deer, smaller rodents and birds that feed on the foliage and bark. Damage and losses can be significant although plants often recover.	Deer damage on *Gmelina arborea* [13.12]

[a] FAO forest health Web page: www.fao.org/forestry/pests

[b] Pest management glossary: www.ipmrc.com/lib/glossary.shtml

[c] Department of Plant Pathology, University of Wisconsin: www.plantpath.wisc.edu/soyhealth/phyhome.htm

Non-living (abiotic) influences

Non-living factors that impair the health of trees are summarized in Table 2. The effects of poor soil and generally adverse growing conditions on the health of trees, and their causal association with observed symptoms, needs careful examination. Nutrient disorders produce symptoms similar to those of virus diseases and other pest infestations or infections, and a lack of information often makes it difficult to make even a preliminary diagnosis of a problem.

Table 2 describes abiotic factors affecting tree health and gives corresponding examples in the colour plates. Note that fire may weaken trees and make them more susceptible to insect attack.

When poor growing conditions have had long-term effects on the health of a tree, an examination of growth rings can help to reveal the history of factors such as prolonged periods of drought. Other evidence may be more immediate and visible. For example, a shortening of internode lengths in neem suggests a number of years of poor growth (see Plate 15.2).

Table 2. Abiotic factors that affect the health of trees

Main factor	Categories and examples	Notes	Corresponding colour plates
Chemicals	Toxic: pesticides, herbicides Pollution: deposition on plant, atmospheric, industrial waste Miscellaneous: salt, oil poured into soil	The role of atmospheric pollution in tree declines may be overstated.	Leaf blight caused by herbicide drift [7.6]
Mechanical agents	Machinery: used in agriculture and for construction Human: malicious, accidental	Mechanical damage can provide means for pathogens (mostly fungi) to enter.	Damage by grass cutting equipment [15.3] Illegal tapping for sap [15.6] Bad pruning allows fungi to enter and establish heart rot [15.10]
Soil conditions	Availability of nutrients: deficiency, excess Physical structure: poor drainage, inhibition of root development	Trees respond in different ways to lack of particular nutrients.	Boron deficiency on *Pinus patula* [15.6] Poor nursery practice [15.9]
Water	Too much: flooding; waterlogging Not enough: drought	Trees differ in their ability to withstand excess or poor availability of water.	Waterlogging [1.4] Drought [6.1]
Weather	Temperature: too low or too high Other: lightning, hail, wind, snow	The effects of climate on tree health are often not immediate.	Frost [15.7] Hail damage [15.1]

5 Describing features of unhealthy trees

Recognizing features of ill health

When is a tree unhealthy? The simple answer is when symptoms are observed in the crown, on the foliage or on stems (shoots, branches, trunks). The impracticality of examining tree roots or failure to do so may mask important evidence, but for serious problems symptoms are usually manifest in other parts of the tree.

The detection of ill health depends on the initial recognition of symptoms. Some symptoms are easy to identify, for example wilted leaves and stems with cankers, but others are not and may be difficult to distinguish from events that occur in the normal cycle of growth. Many trees drop their leaves and stop growing during winter or dry seasons. It is therefore important to understand the tree's normal pattern of growth throughout the year and from one year to the next, according to prevailing conditions at particular sites.

Symptoms and their classification

A scheme for classifying symptoms is presented in Table 3. This is based on a comprehensive review of symptom descriptions and categories presented mostly in books on tree pests. The basis for the scheme is the *CABI crop protection compendium* (see Annex 2), which includes a comprehensive listing of symptoms resulting from biotic and abiotic factors. As shown in the colour plates, similar features can have very different causes. A classification of tree health problems by symptoms will inevitably include more than one type of cause in some categories.

Table 3. Categories of symptoms of ill health

CATEGORY/FEATURE	NOTES	CORRESPONDING COLOUR PLATES
Altered growth or development		
Colour changes in crown	Change of colour; loss of colour (discolouration)	1A, 1B
Change in form or shape	Galls, swellings and knots; cracked or split surface, distorted leaves and stems, malformation	2, 3
Growth disturbance	Growth stimulation; stunted or reduced growth	4, 5
Premature loss or development	Early leaf drop, senescence or ripening	6
General death		
Blight	Characterized by widespread and rapid killing of plant parts (i.e. leaves, flowers, stems)	7
Dieback	Progressive death of shoots, leaves or roots, beginning at the tips	8
Wilt and collapse	Drooping of plants as a result of insufficient water supply	9
Localized death or necrosis		
Spots and lesions	Many words are used to describe these small localized areas in addition to the common "leafspot", e.g. blotches, scabs, pits	10
Cankers	Cankers vary from those with sunken centres to others with raised edges and some with more general swellings	11A, 11B
Rots and decays	Rots and decays, commonly occurring inside major stems or trunks	12
Physical evidence		
Damage by animal and insect feeding	Exit holes, frass, webbing, internal or external shredding, spittle mass	13A, 13B
Pest infestation	Visible insects, visible fungal sporing structures (e.g. bracket fungi), mycelium, growth of moulds or sooty appearance	14A, 14B
General damage	Bleeding, ooze (not bacterial); mechanical damage; adverse climatic conditions	15A, 15B
Other growths on trees	Parasitic plants, epiphytes, lichens, mosses, algae	16

6 Analysing the cause of symptoms

Interpretation of symptoms

The fundamental challenge is to realize when a tree is unhealthy.

The following stages are suggested for interpreting symptoms and making diagnoses from visual evidence only:

1. Learn the expected appearance of the tree given where it is growing, the time of year and the prevailing conditions. Seek advice if necessary.
2. Observe the symptoms. Start with a close-up examination of plant parts, consider the distribution of symptoms in individual trees, and then examine the distribution of affected trees at the site. Last, find out from foresters and local people about the history of the problem (see Chapter 7). Make thorough notes, as accurate information will be required if you request technical assistance.
3. Use the classification in Table 3 to decide what types of symptoms are present. Examine the colour plates for symptoms that are similar to those found on the affected tree. This will suggest possible causes. Refer to Annex 3 to review which tree species and problems are illustrated in the colour plates.
4. If further investigations are required (for example, if many trees are dying), take samples. Look carefully for any evidence of pest activity; collect pest samples or plant samples showing early symptoms from the appropriate part of the tree using the guidelines in Chapter 8.
5. Consult the references in Annex 2 for further information.

Making a diagnosis

Many stages are involved between the first observations of symptoms and the final conclusion about their cause. The first step is to eliminate factors that are most unlikely to be the cause of the problem. For some symptoms the cause may be easily determined, as with the pustules on leaves produced by a rust fungus, for example (Plate 2.2). Other symptoms may have several possible causes, such as dieback (Plate 8), which could be the result of a mammal feeding on a stem and stripping away the bark (Plates 13.13, 7.8), a fungal root disease (Plate 1.3) or a phytoplasma infection (Plate 4.7). Resolving these problems may involve the identification of potential pest organisms. This can be a long and complicated procedure, hence the value of carrying out a preliminary diagnosis.

A good diagnosis takes into account wide knowledge of the host tree, the causal factors that impair its health and the interactions between the host, the factors and the environment in which the tree grows. Identifying the precise cause of a problem is often difficult, yet much can be achieved by following the simple procedures described above.

Problems in linking symptoms to causes

Some difficulties may be experienced in observing and interpreting the wide range of symptoms illustrated in the colour plates (Table 4). Tree health problems are often assumed to be caused by insects because they are easy to find on trees and also because alternative causes of ill health are often unknown (see Table 2). The supporting evidence should always be examined carefully in interpreting the significance and importance of insects and other external features such as bracket fungi on trunks. The role of atmospheric pollution in tree declines should also be examined carefully by reference to the extensive literature on this topic (see Annex 2).

Table 4. Common difficulties in observing and interpreting symptoms

DIFFICULTY OR PROBLEM	EXAMPLES	WHY?	CORRESPONDING COLOUR PLATES
Symptom type not recognized	Phytoplasma diseases, e.g. gliricidia little leaf disease	General unfamiliarity with phytoplasma and virus diseases on trees	1 [e.g. 1.2, 1.9] 4 [e.g. 4.3]
Incorrect diagnosis of symptoms	Confusion between the effects of insect infestation and other pests	Insects are easy to see; poor awareness about the symptoms associated with other pests	13, 14
Significance of symptoms not fully understood	Root disturbances leading to dieback and loss of vigour in crown	Unfamiliarity with root diseases and their pest causes	8, 14A
Unwarranted alarm about physical evidence of damage to tree	Termite feeding on mature tree trunks	Unawareness that bark feeders cause only superficial damage that has no effect on the health of the tree	14.8

7 Colour plates: examples of ill-health in trees

The colour plates give visual examples of different types of symptoms and damage associated with tree health problems. They are organized according to the classification of symptoms described in Table 3, Chapter 5. The captions describe the problem and give the name of the pest or other factors responsible for the symptoms. The host name and site are included in the caption. Colour plates can be searched by tree host and health problem in Annex 3.

Colour plates

Altered growth or development

Plates 1A, 1B: COLOUR CHANGES IN CROWN
Plate 2: GALLS, SWELLINGS AND KNOTS
Plate 3: DISTORTION OF LEAVES AND STEMS
Plate 4: GROWTH STIMULATION
Plate 5: STUNTED OR REDUCED GROWTH
Plate 6: PREMATURE LOSS OF LEAVES OR STEMS

General death

Plate 7: BLIGHT
Plate 8: DIEBACK
Plate 9: WILT AND COLLAPSE

Localized death

Plate 10: SPOTS AND LESIONS
Plates 11A, 11B: CANKERS
Plate 12: ROTS AND DECAYS

Physical evidence

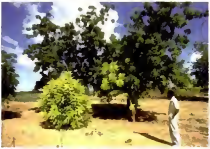
Plates 13A, 13B: DAMAGE BY INSECT AND ANIMAL FEEDING
Plates 14A, 14B: PEST INFESTATION
Plates 15A, 15B: GENERAL DAMAGE
Plate 16: OTHER GROWTHS ON TREES

Plate 1A

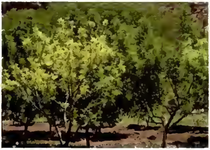
ALTERED GROWTH OR DEVELOPMENT

Colour changes in crown

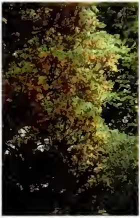
The examples in Plates 1A and 1B illustrate a wide variety of causes. Nutrient disorders and "site factors" are often said to be the cause of poor health, as determined by the appearance of crowns. But also look out for symptoms such as smaller leaves [1.2] and unusual patterns of leaf discolouration [1.5].



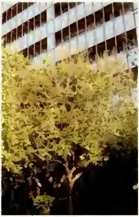
1.1 Unknown cause, possibly genetic abnormality. No evidence of pest attack. Only one tree affected. *Azadirachta indica*, Niger.



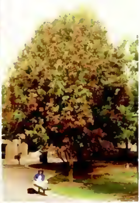
1.2 Suspected peach yellows (left), phytoplasma disease. Leaves are smaller than on healthy trees. *Prunus persica*, Camargo, Bolivia.



1.3 Fungal root disease is the suspected cause of these foliar symptoms and decline. *Austrocedrus chilensis*, Bariloche, Argentina.



1.4 Waterlogging. All trees affected and several nearby ones have already died. *Celtis africana*, Pretoria, South Africa.



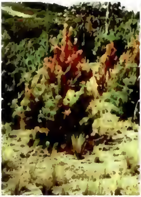
1.5 Bacterial leaf scorch caused by *Xylella fastidiosa*, is a systemic disease. *Quercus velutina*, Raleigh, North Carolina, USA.

Plate 1B

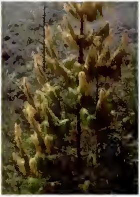
ALTERED GROWTH OR DEVELOPMENT

Colour changes in crown

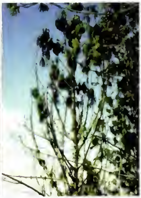
Not all changes in colour indicate disease or insect attack [1.10]. Always compare the suspected problem with the condition or appearance of trees at different times of year. Nutrient imbalances in the soil are often blamed for colour changes and other altered growth responses, but little information exists about this for non-commercial tree species.



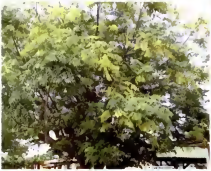
1.6 Drought damage. Trees weakened by poor planting. *Pinus patula*, Venezuela.

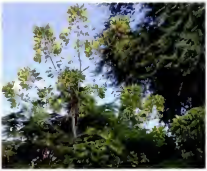


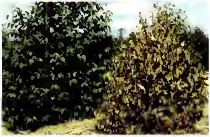
1.7 Probably drought damage. *Pinus sp.*, Chuquisaca, Bolivia.



1.8 Boron deficiency, a recognized condition on *Pinus patula*. Colombia.







1.9 [above left] Yellows disease (and dieback) due to phytoplasma disease. *Melia azedarach*, Santa Cruz de la Sierra, Bolivia.

1.10 [above right] Normal loss of foliage and colour change as the dry season begins. *Toona ciliata*, Zomba, Malawi.

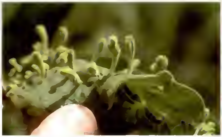
1.11 [left] Note the discolouration throughout the tree, the result of fungal canker damage caused by *Cryphonectria cubensis* on the main stem (not visible in this photo). *Eucalyptus* sp., Brazil.

Plate 2

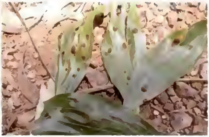
ALTERED GROWTH OR DEVELOPMENT

Galls, swellings and knots

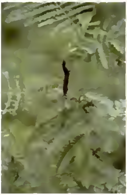
Swelling on stems can be slight [2.3] or pronounced. Galls are highly distinctive and often diagnostic for specific pests.

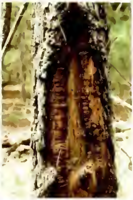


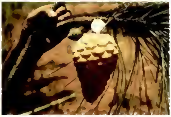
2.1 Mite-induced galls causing significant damage in nurseries. *Vangueria infausta*, Gaborone, Botswana.



2.2 Galls of the rust fungus, *Atelocauda digitata*. *Acacia mangium*, Kalimantan, Indonesia.



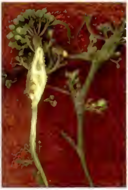


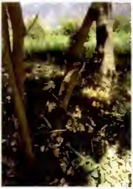


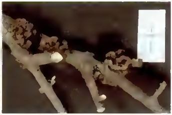
2.3 [left] Rust fungus, *Diorchidiella verlandii* infests stems and also causes dieback in crown. *Mimosa schomburgkii*, Vicosa, Brazil.

2.4 [middle] Swelling at edge of canker is part of the healing process. *Pinus* sp., Brazil.

2.5 [above] Rust infection causes enlargement of pine cone. *Cronartium strobilinum* on *Pinus elliottii*, USA.







2.6 [left] Note swelling below the flowering region, possibly due to the pink fungus fruiting on the surface. *Calliandra calothyrsus*, Trujillo, Honduras.

2.7 [middle] Crown gall caused by *Agrobacterium tumefasciens*. *Inga edulis*, Rio Chico, Bolivia.

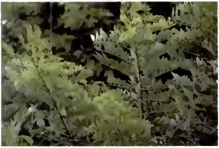
2.8 [above] Olive knot caused by the bacterium *Pseudomonas savastanoi*. *Olea europaea*, Spain.

Plate 3

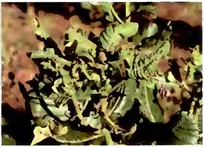
ALTERED GROWTH OR DEVELOPMENT

Distortion of leaves and stems

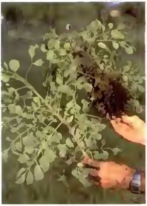
A variety of pests can distort leaves and sometimes young, still fleshy stems. The effects can be transient [3.2], as in some incidences of insect feeding, but other altered growth forms can be accompanied by serious losses [3.3].



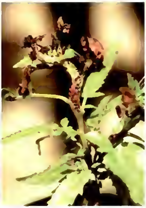
3.1 Virus disease produces distorted (shoestring) leaves on youngest stems. *Gliricidia sepium*, Vado Hondo, Guatemala.



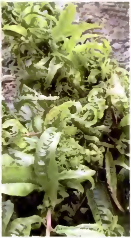
3.2 Leaf curling and death of stems of unknown origin. Possibly due to insect feeding or virus disease. *Uapaca kirkiana*, Zomba, Malawi.

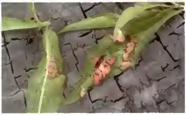


3.3 Stubby shoot disease reduces flowering and fruit production. Cause unknown. *Sclerocarya birrea*, Gaborone, Botswana.



3.4 Psyllid attack (*Calophya rubra*) produces pits on stems and leaves and weakens them. *Schinus molle*, Cochabamba, Bolivia.





3.5 [above, right] Symptoms of aphid damage considered by some farmers to be related to those shown left for peach leaf curl and called by the same name. *Prunus persica*, Sucre, Bolivia.

3.6 [left] Peach leaf curl, a highly distinctive fungus disease caused by *Taphrina deformans*. *Prunus persica*, Epizana, Bolivia.

Plate 4

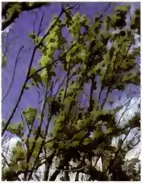
ALTERED GROWTH OR DEVELOPMENT

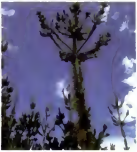
Growth stimulation

Infection or pest attack can cause extra or additional growth which is often weaker than normal and may lead to dieback.

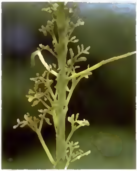
4.1 [right] Extensive sprouting of leaves along stems in declining trees associated with ash yellows, a phytoplasma disease. *Fraxinus udhei*, Bogotá, Colombia

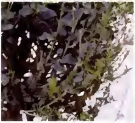
4.2 [far right]. Foxtailing is linked with predisposing genetic traits plus environmental influences. *Pinus* sp., Cochabamba, Bolivia.





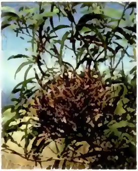
4.3 [below]. Increased leaf production on very young stems soon falls off. Glincidia little leaf disease, caused by a phytoplasma. *Glincidia sepium*, Honduras.

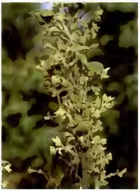




4.4 [above] Animal grazing has stimulated new growth on right. Unknown street tree, Cochabamba, Bolivia.

4.5 [right] Witches' broom caused by the rust fungus *Endoraecium acaciae*. *Acacia koaia*, Hawaii.





4.6 [left] Additional shoots formed with apparently smaller leaves. This type of symptom is difficult to interpret on unfamiliar trees. Suspected phytoplasma disease. *Azanza garckeana*, Gaborone, Botswana.

4.7 [right] Spectacular growth at top of this tree is due to phytoplasma infection. *Aphanamixis polystachya* (Meliaceae), Dinajpur, Bangladesh.

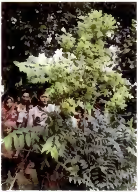
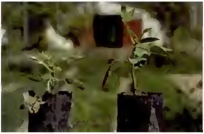


Plate 5

ALTERED GROWTH OR DEVELOPMENT

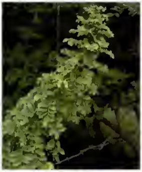
Stunted or reduced growth

Reduced growth may indicate poor growing conditions [5.1]. Major losses can occur when pests are not involved [5.4].



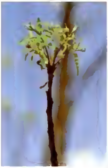
5.1 Compare reduced growth on left with seedling on right. Poor nutrition or lack of water are possible causes. No obvious indication of virus disease. *Erythrina falcata*, Cochabamba, Bolivia.

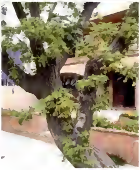
5.2 This native species grows up to 4,000 masl and beyond, but here it is performing poorly at 2,500 masl. Cause of "problem" is not known but could simply be poor nutrition. *Polylepis incana*, Cochabamba, Bolivia.



5.3 [left] Gliricidia little leaf disease (phytoplasma). Internode length is greatly reduced giving this densely foliated stem. *Gliricidia sepium*, Zamorano, Honduras.

5.4 [right] Greatly reduced internodes, barren lower stems and bunches of small leaves at the apex are known as "giraffes' necks", a symptom of neem decline. Thought to be associated with drought *Azadirachta indica*, near Sokoto, Nigeria.





5.5 [left] Melia yellows disease. Stimulation of growth from main trunk. Leaves are much smaller and internode length is reduced, hence the compact bunches. These leaves soon die and fall away. *Melia azedarach*, Cochabamba, Bolivia.

5.6 [right] Healthy foliage shown on the left and that caused by phytoplasma disease shown on the right. *Melia azedarach*, Bolivia

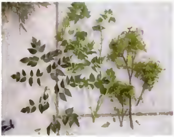
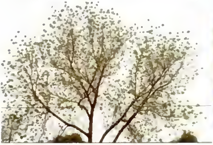


Plate 6

ALTERED GROWTH OR DEVELOPMENT

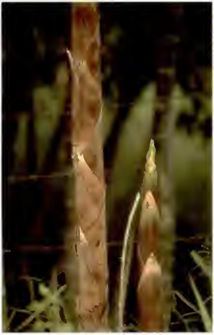
Premature loss of leaves or stems

Early drop of leaves is linked to pest [6.2] and non-pest [6.1] causes although in the former case trees would usually exhibit other symptoms such as root decay. The effect of abiotic influences such as drought is often temporary with trees becoming healthy as more rain falls. Pathogens and diseases have more fundamental and longer-term impacts on tree health.

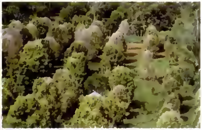


6.1 Sparse crowns and early leaf drop as well as giraffe neck symptoms indicate neem decline. Thought to be associated with drought. *Azadirachta indica*, Damaturu, Nigeria.

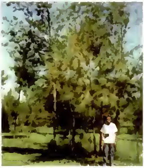
6.2 Loss of leaves is due to phytophthora root disease. *Alnus glutinosa*, Sussex, UK.



6.3 Premature death of culm sheaths is the first sign that culm tissues below are dying. *Guadua angustifolia*, Quindio, Colombia.



6.4 Loss of leaves is due to a bacterial wilt disease caused by *Pseudomonas syzygii*, known as Sumatra disease. *Syzygium aromaticum*, North Sumatra, Indonesia.



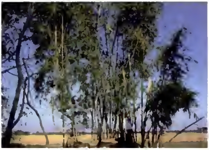
6.5 Loss of foliage (and yellowing) due to bacterial wilt caused by *Ralstonia solanacearum*. *Casuarina equisetifolia*, China.

Plate 7

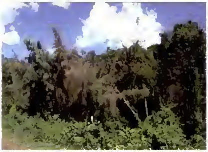
GENERAL DEATH

Blight

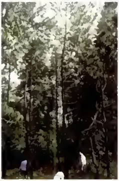
Blight is a general term used to describe death of foliage or stems, often in the absence of any distinctive symptom.

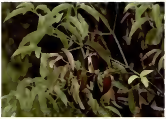


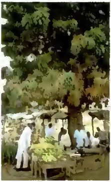
7.1 Bamboo blight, suspected fungal disease. Note brown, dead portions of blighted culms. *Bambusa vulgaris*, Chittagong, Bangladesh



7.2 Dying bamboo in foreground which looks like blight, is due to flowering of bamboo *Arundinaria alpina*, Ethiopia.



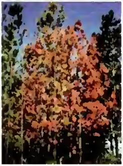


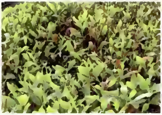


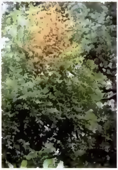
7.3 [above] Web blight caused by the fungus *Koleroga noxia*. Such blights are common on many plants and are caused by various fungi. *Theobroma cacao*, Tingo Maria, Peru.

7.4 [left] Loss of leaves above confirms advanced root disease, probably due to the fungus *Ganoderma* sp. *Acacia mangium*, Riau, Indonesia

7.5 [right] Neem scale insect, *Aonidiella orientalis*. *Azadirachta indica*, eastern Nigeria on the Cameroon border.







7.6 [above]. Leaf blight (scorch) caused by herbicide drift in nursery. *Acacia mangium*, Kalimantan, Indonesia.

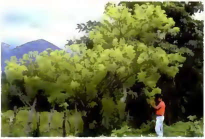
7.7 [left] Attack by the fungus *Botryosphaeria dothidea* *Pinus taeda*, Hawaii, USA.

7.8 [right] Patch of brown and dried-up leaves indicates mammal feeding on stem, probably by squirrels. *Betula pendula*, Sussex, UK.

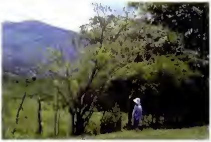
Plate 8

GENERAL DEATH
Dieback

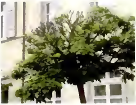
Note that not all stems without leaves in the crown are necessarily dead. Dieback is associated with many different causes, from root and trunk diseases to the broader effects of poor growing conditions and waterlogging.



8.1 Note minor dieback at left due to little leaf disease (phytoplasma). The yellow foliage is also abnormal. *Gliricidia sepium.* Jutiapa, Guatemala.

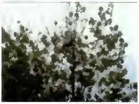


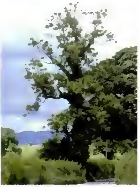
8.2 Same tree as 8.1 photographed exactly one year later. Note more extensive dieback.



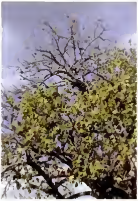
8.3 [left] Dieback due to unknown cause in street tree. *Catalpa bignonioides*, Baden-Baden, Germany.

8.4 [right]. Apparent dieback. Birds have stripped the foliage to make nests but stems may still be alive. *Azadirachta indica*, Garoua, Cameroon.

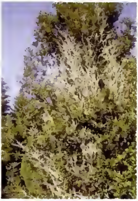




8.5 Dieback is common in hedgerow trees whose roots may be affected by agricultural practices. No primary involvement of pests. *Fraxinus excelsior*, UK.



8.6 Dieback possibly due to mechanical interference with root system. *Sterculia quinqueloba*, Mangochi town, Malawi.



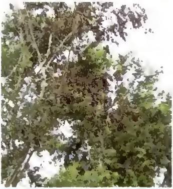
8.7 Dieback due to possible ganoderma root disease. *Nothofagus* sp., Rotorua, New Zealand

Plate 9

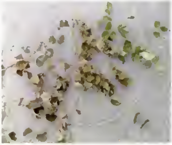
GENERAL DEATH

Wilt and collapse

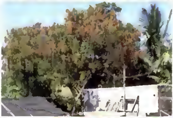
Wilting of foliage is often less distinctive in woody hosts when compared to the wilting of fleshy leaves of annual crops. Wilts are the result of internal blockages and are often accompanied by internal staining of stems [9.5]. Note that obtaining clear photos of wilt symptoms in crowns is often difficult; affected branches should be removed and photographed separately



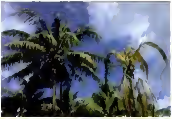
9.1 [left] Wilt symptoms Thought to be associated with fusarium root disease *Dalbergia sissoo*, near Bogra, Bangladesh



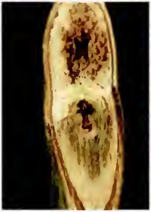
9.2 [above] Close-up of the wilt and "blighted" leaves shown in **9.1**



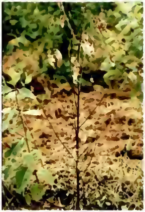
9.3 [left] Feeding by the tea mosquito, *Helopeltis antonii*, induces wilt-like symptoms. *Azadirachta indica*, India



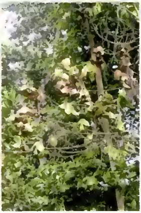
9.4 [right] Lethal yellowing disease of palms *Cocos nucifera*, Florida, USA



9.5 Internal staining and bacterial ooze (appears brown). See **9.6** for wilt symptoms. *Eucalyptus* sp., Mexico



9.6 Bacterial wilt, caused by *Ralstonia solanacearum*. *Eucalyptus* sp., Mexico.



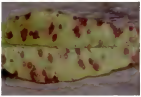
9.7 Takamaka wilt caused by the fungus *Leptographium calophylli*. *Calophyllum inophyllum*, Praslin, Seychelles.

Plate 10

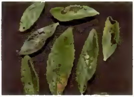
LOCALIZED DEATH

Spots and lesions

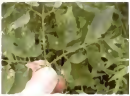
Spots and lesions are common and it is not always easy to distinguish between insect feeding, fungi, bacteria, viruses and the effects of nutrient disorders. With stem lesions, carefully remove tissues to look for necrosis below [10.6].



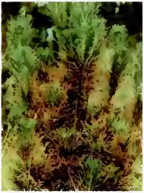
10.1 Lesions possibly due to the fungus *Kirramyces* sp. *Eucalyptus* sp., Thailand



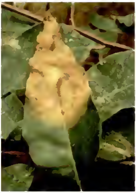
10.2 Common leaf spots associated with the fungus *Septoria* sp. *Polylepis incana*, Bolivia.



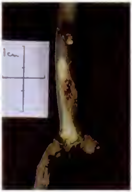
10.3 Fungal leaf spots caused by *Cercospora meliae*. *Melia azedarach*, Dinajpur, Bangladesh



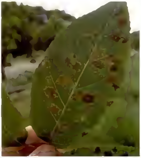
10.4 Dothistroma blight. Banding and colour changes occur on needles rather than distinct spots. *Pinus radiata*, Ecuador.



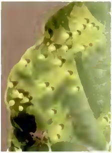
10.5 Some fungal infections affect large areas rather than cause distinct spots. *Cylindrocladium* sp. on *Eucalyptus urophylla*, Brazil.



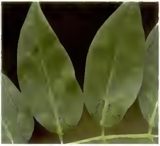
10.6 Young bacterial cankers (*Pseudomonas savastanoi*) that lack the corky appearance of older lesions. *Fraxinus excelsior*, Yorkshire, UK



10.7 Fungal leaf scabs caused by *Apiosphaeria guaranitica*. *Tabebuia serratifolia*, Vicosa, Brazil



10.8 Insect galls and yellowing. *Ficus sycomorus*, Mangochi, Malawi



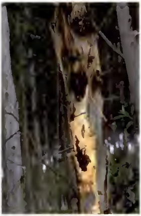
10.9 Suspected virus-caused discolouration and flecking on foliage. *Gliricidia sepium*, Honduras

Plate 11A

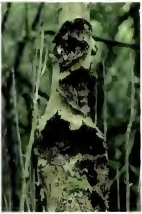
LOCALIZED DEATH

Cankers

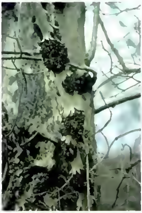
Cankers can vary considerably in appearance: some have raised edges and cavities while others look more like galls or knots. The underlying tissues should be examined to see if there is necrosis and evidence of disease.



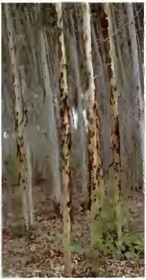
11.1 Serious and fatal fungal canker caused by *Coniothyrium zuluense*. *Eucalyptus* sp. Kwazulu, South Africa. Also shown below in **11.5**

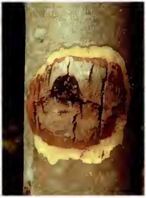


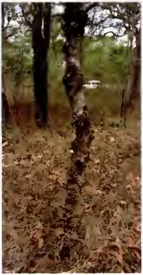
11.2 Contrast these fungal cankers caused by *Nectria galligena* with the bacterial cankers shown in **11.3**. *Fraxinus excelsior*, Surrey, UK.



11.3 Bacterial cankers casued by *Pseudomonas savastanoi* sometimes referred to as "knots". *Fraxinus excelsior*, Yorkshire, UK.







11.4 [above] Fungal canker due to *Cryphonectria cubensis*. *Eucalyptus* sp , Brazil

11.5 [left] Fungal cankers, *Coniothyrium zuluense*. *Eucalyptus* sp , KwaZulu, South Africa

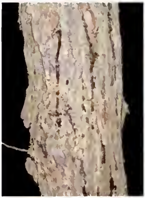
11.6 [right] Canker or knot of unknown origin *Uapaca kirkiana*, Perekezi, Malawi

Plate 11B

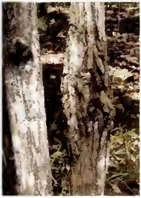
LOCALIZED DEATH

Cankers

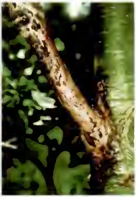
Some cankers do not have large cavities [11.7]. Note the features of gummosis on eucalypts [11.12 and 11.13].



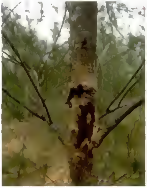
11.7 Bleeding from *Seiridium cardinale* fungal cankers. *Cupressus lusitanica*, Pretoria, South Africa.



11.8 Cankers associated with several different fungi. *Acacia* sp., Kalimantan, Indonesia.

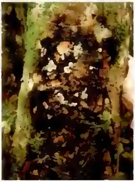


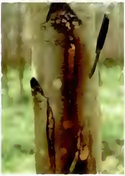
11.9 *Hypoxylon mammatum*, fungal canker. *Populus* sp., USA.



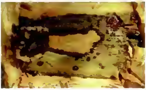
11.10 [left] Blister bark disease caused by a fungus. *Casuarina equisetifolia*, Karnataka, India.

11.11 [right] Canker due to *Phellinus noxius*. *Hevea brasiliensis*, Kalimantan, Indonesia.





11.12 [above] Gummosis, a symptom associated with abiotic factors. *Eucalyptus* sp., place unknown.



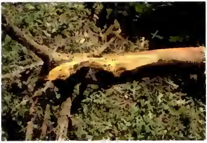
11.13 [left] Dark areas above exposed to show exudation of liquid known as kino.

Plate 12

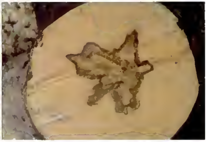
LOCALIZED DEATH

Rots and decays

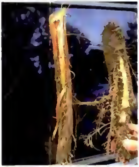
Rots and decays are classified according to the place where they occur, e.g. heartrot [12.2] or according to colour [12.3]

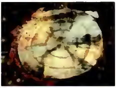


12.1 Suspected pythium root infection. *Eucalyptus* sp., KwaZulu, South Africa.



12.2 Suspected *Ganoderma* sp. infection. *Acer pseudoplatanus*, France.

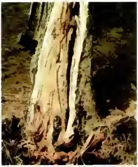


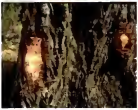


12.3 [above] Bluestain caused by various fungi. *Pinus caribaea* var. *hondurensis*, Venezuela.

12.4 [right] Root and butt brown (cubicle) rot associated with *Laetiporus sulphureus*. *Casuarina equisetifolia*, Senegal.

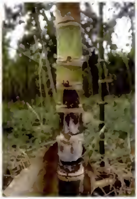
12.5 [left] Root rot, probably *Ganoderma* sp. *Acacia mangium*, Riau, Indonesia.

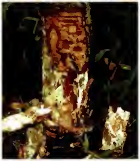




12.6 [above] Healthy tissue on left, decay on right, associated with decline. *Austrocedrus chilensis*, Bariloche, Argentina.

12.7 [right] Secondary fungal growth on culm surface. Suspected bacterial disease has caused decay. *Guadua angustifolia*, Quindio, Colombia.





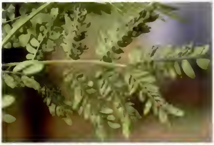
12.8 Fungal mats of *Armillaria mellea*, a widespread cause of root rot and tree death in temperate and subtropical areas. *Metrosideros polymorpha*, Hawaii.

Plate 13A

PHYSICAL EVIDENCE

Damage by insect and animal feeding

Observing insects feeding on foliage is not always possible although some types of damage are unmistakable [3.7].

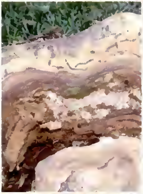


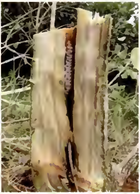
13.1 [left] Psyllid infestation (*Heteropsylla cubana*). *Leucaena leucocephala*, Nepal.

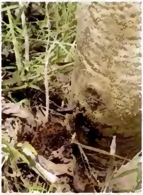
13.2 [below, left] Tunnels made by unknown beetle larvae. *Pterocarpus indicus*, Mahe, Seychelles.

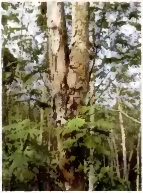
13.3 [below, middle] Beehole borer, *Xyleutes ceramicus* in young tree. *Gmelina arborea*, Kalimantan, Indonesia.

13.4 [below, right] Empty larval case and frass is evidence of internal feeding by the beehole borer shown in **13.3**. Photographs from same tree.

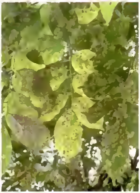




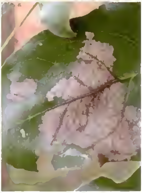




13.5 Bark feeding by *Phoracantha* sp. Sprouting below dead region of trunk. *Paraserianthes falcataria*, Kalimantan, Indonesia.



13.6 Leaf miner (Neolithocolletis pentadesma) damage. *Pterocarpus indicus*, Mahe, Seychelles.



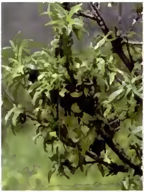
13.7 Leaf skeletonizer (insect feeding damage). *Uapaca kirkiana*, Mzuzu, Malawi.

Plate 13B

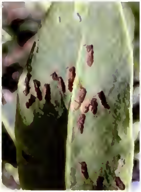
PHYSICAL EVIDENCE

Damage by insect and animal feeding

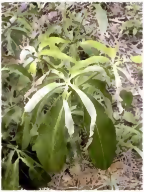
Wilting of foliage in [13.11] and [13.13] is due not to systemic infection by pathogens but to animals feeding on the bark. Trees usually recover the following year.



13.8 Aphid feeding. Black material is fungal growth, "sooty mould". *Prunus persica*, Pocona, Bolivia.

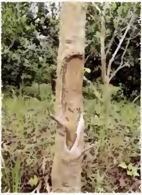


13.9 Grazing by unidentified insect. Unknown host, Mahé, Seychelles.

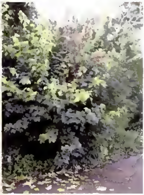


13.10 Leaf tier. Name of insect not known. *Dillenia* sp., Kalimantan, Indonesia.

13.11 Feeding damage (squirrels) similar to that shown in **13.13**. *Acacia mangium*, Kalimantan, Indonesia



13.12 Feeding damage by deer. *Gmelina arborea*, Indonesia



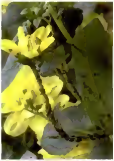
13.13 Bark stripping by squirrels leads to wilt and chlorosis. *Acer pseudoplatanus*, Surrey, UK

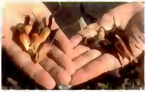
Plate 14A

PHYSICAL EVIDENCE

Pest infestation

Infestations are easy to observe and often cause concern, but their significance may be less than assumed.

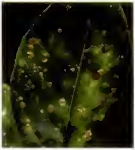


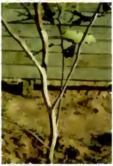


14.1 [above] Rust fungus *Uleiella paradoxa* kills seeds and forms black masses. *Araucaria araucana*, Dead China, Chile.

14.2 [left] Aphids feeding. Unknown shrub, Cochabamba, Bolivia.

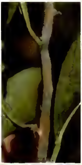
14.3 [right] Scale insect. Citrus, Trinidad, Bolivia.

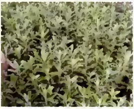




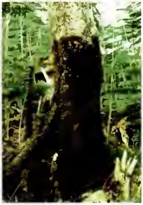
14.4 [left] White mycelial sheath of *Erythricium salmonicolor*. *Eucalyptus* sp., Brazil.

14.5 [right] Velvet mould due to growth of the fungus *Septobasidium* sp. Citrus, Santa Cruz, Bolivia.

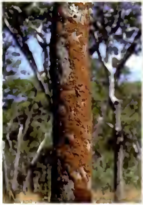




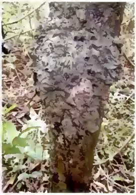
14.6 [above] Powdery mildew as shown by white bloom on leaves. *Buddleja* sp., Cochabamba, Bolivia



14.7 Dark mycelial mat of *Phellinus noxius*. *Delonix regia*, Saipan Island, Marianas.



14.8 Termites surface feeding on bark, not damaging. *Brachystegia* sp., Malawi.

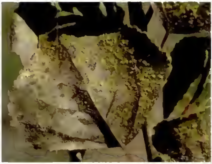


14.9 Termite nest (empty). *Paraserianthes falcataria*, Kalimantan, Indonesia.

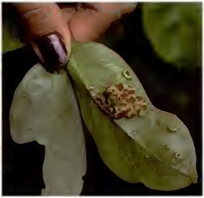
Plate 14B

PHYSICAL EVIDENCE

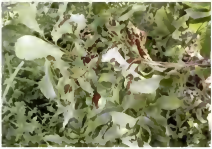
Pest infestation



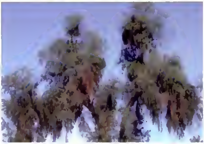
14.10 Rust fungus (*Melampsora allii-populina*). *Populus* sp., Cochabamba, Bolivia



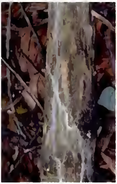
14.11 Rust fungus (*Chaconia ingae*) with raised pustules. *Inga cylindrica*, Santa Cruz, Bolivia

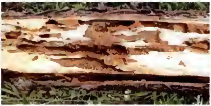


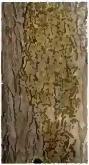
14.12 Gall mite (*Aceria litchii*) on lychee seen as "fur" on underside of leaves. *Litchi chinensis*, Thai Nguyen, Viet Nam.



14.13 Parasitic plant in crown as shown by the red flowers of *Ligaria cuneifolia*. *Schinus molle*, Santa Cruz, Bolivia







14.14 [above] Root feeding termites (*Coptotermes* sp.) can cause severe damage *Gmelina arborea*, Kalimantan, Indonesia

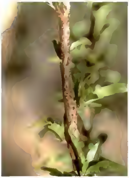
14.15 [left] Pink disease caused by *Corticium salmonicolor* affects many species. *Acacia* sp , Sumatra, Indonesia

14.16 [right] Aggregation of larvae known locally as sika sika (? *Tolype* sp) *Schinus molle*, Cochabamba, Bolivia

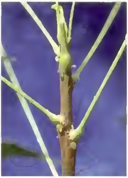
Plate 15A

PHYSICAL EVIDENCE
General damage

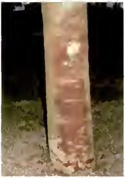
Unusual growth events [15.2] or damage [15.3] are best resolved by first looking for evidence of necrosis and then making enquiries about possible sources of mechanical damage.



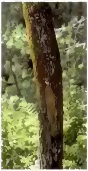
15.1 Hail damage. The scars have healed over the original damage. *Prunus persica*, Nor Cinti, Bolivia.

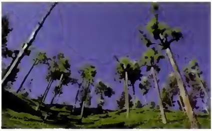


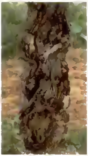
15.2 Drought-induced. The ooze is from extra-floral nectaries. Note shortening of internode length. *Azadirachta indica*, Nigeria



15.3 Damage by grass cutting equipment. *Acacia xanthophloea*, Pretoria, South Africa



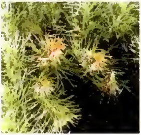


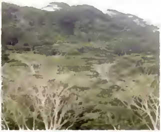


15.4 [above] Damage caused by pruning for shade above tea plantation. *Grevillea robusta*, Tamil Nadu, India.

15.5 [left] Tapping for resin. *Pinus merkusii*, Central Java, Indonesia.

15.6 [right] Illegal tapping for sap, which is used to make an alcoholic beverage. *Acacia* sp., Karnataka, India.





15.7 [left] Frost damage. *Pinus radiata*, Rotorua, New Zealand.

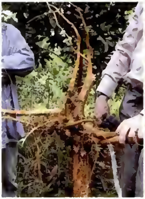
15.8 Deliberate ring-barking of trees is killing them. *Paraserianthes falcataria*, Mahe Seychelles.

Plate 15B

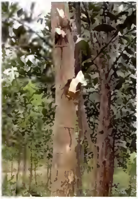
PHYSICAL EVIDENCE

General damage

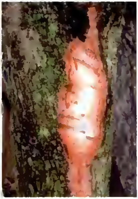
Bad pruning is a common source of future problems as the cut surfaces allow the entry of potential pathogens. Poor planting stock weakens future growth and makes trees more susceptible to insect attack.



15.9 Poor nursery practice leads to twisted roots. Trees grow poorly. *Acacia mangium*, Kalimantan, Indonesia.



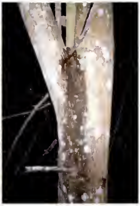
15.10 Ragged pruning allows fungi to enter and establish heart rot. *Acacia mangium*, Kalimantan, Indonesia.



15.11 Normal sap bleeding. Guides cut trees for tourists and this results in scars. *Pterocarpus indicus*, Mahe, Seychelles.

15.12 Pruning to remove overhanging branches. *Fraxinus udhei*, Bogotá, Colombia.

15.13 Pruning to avoid interference with electrical cables, but clumsily performed *Fraxinus udhei*, Pereira, Colombia



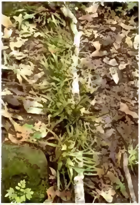
15.14 Flux from junction of main trunks. Cause unknown. Trees "bleed" for physiological and pathological reasons. *Acacia auriculiformis*, Kalimantan, Indonesia.

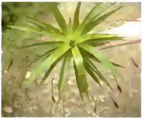
Plate 16

PHYSICAL EVIDENCE

Other growths on trees

Although plants and lichens do not cause direct harm to trees, they may have some effect or importance. Lichen patterns on stems may superficially resemble possible pathogenic fungi [16.6]

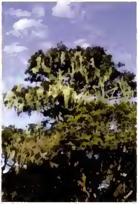


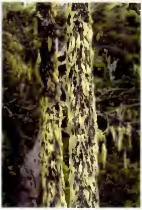


16.1 [above] One of several common bromeliads found on cocoa. *Theobroma cacao,* Equador

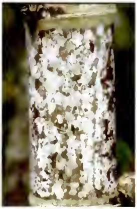
16.2 [left]. Epiphytic plants (bromeliads) weigh down branches. *Theobroma cacao,* near Quevedo, Ecuador.

16.3 [right] Lichens festoon the crowns of several trees in the miombo woodlands. Mzuzu, Malawi.

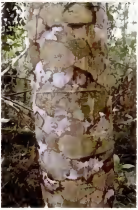




16.4 Lichen growths. *Araucaria araucana,* Dead China, Chile.



16.5 Lichens growing on culms. *Guadua angustifolia,* Quindio, Colombia.



16.6 Colourful patterns on trunk due to several species of lichens. *Paraserianthes falcataria,* Indonesia.

8 Integrating different sources of knowledge

Sources of knowledge on tree health range from the forester and extension officer to the researcher. Surveys are the traditional way of determining the incidence and severity of a problem, but they require time, vehicles and money. Surveys also depend on the availability of researchers and local staff, which tend to be increasingly few. Local knowledge is a frequently neglected source of information which can provide fresh insights and a wider perspective on tree health problems without the need for expensive and lengthy surveys.

Many local people rely on trees for products and services and carefully observe changes to the health of trees. These observations often lack scientific detail but are valuable for their potential to describe a problem and to suggest fruitful lines of investigation. The ability of local people to diagnose symptoms accurately may be limited, and separate problems may be considered as the same one (see Plates 3.5 and 3.6). However, careful interviews can be extremely helpful in explaining the history of a disease or disorder, when it first occurred or where it is most damaging. This information can save time and money and contribute new information that would otherwise be difficult or even impossible to collect.

The scientific literature is a more traditional source of information (see Annex 2). The Internet offers unlimited access to information, but it is recommended that directed searches be performed via the useful sites suggested in Table 5.

Table 5. Important Internet sites

WEBSITE	NOTES
www.cabicompendium.org	The forestry compendium has some information on insect pests and diseases (less so on disorders or abiotic factors); the crop protection compendium includes some tree species
www.cabi-bioscience.org	CABI online databases, compendia and published abstracts are frequently available through universities, libraries and research institutes
www.fao.org www.fao.org/forestry/pests	Provides definitions, gives links to other information sources and outlines FAO's activities in forest health
www.fs.fed.us/foresthealth	Provides good information notes on specific forest pests
www.forestryimages.org	Photos of insect pests and diseases on trees, mostly in North America and Europe
www.for.gov.bc. ca/tasb/legsregs/fpc/fpcguide/health/Htoc.htm	Generic forest health surveys guidebook
www.worldagroforestrycentre.org	Provides information on locations, contacts, programmes and activities of the World Agroforestry Centre (ICRAF)
iufro.boku.ac.at	Provides information on contacts, programmes and activities of the International Union of Forestry Research Organizations (IUFRO). Division 7 covers forest health
www.ifgb.uni-hannover.de/extern/ppigb/ppigb.htm	Gateway to information on plant diseases
www.diagnosis.co.nz	Software that helps with diagnosis of crop problems
www.uwasa.fi/comm/termino/collect/forestry.html	Glossary of forestry terms in several languages

9 Technical support and advice

Diagnostic and advisory services

Always consult local support services for initial advice if possible. If these are unavailable for tree health problems, then it is advisable to consult experts and field workers in related disciplines and sectors such as plant pathology and entomology. The next step may be to collect samples or to invite experts to examine the problem in the field.

If samples are required for laboratory investigation, always try to choose a laboratory or institute as close as possible to the site of the tree health problem. A straightforward diagnostic investigation will involve examination of potential pest-infested material, either in the form of insect samples or perhaps plant tissues with fungal fruiting structures. A more detailed investigation will require isolation and identification of potential pest organisms or rearing of adult insects from larvae.

Always contact the laboratory before sending material to determine its policy for accepting samples or receiving cultures or samples of pest organisms, especially if the laboratory is overseas and quarantine legislation must be respected. Common services available include identification of insects, at least to major orders. Fungi that produce spores on plant material are usually more easy to identify than those that require isolation and culturing. Identifying bacteria is more difficult, while services for identifying viruses and phytoplasma are rare.

Diseased material can be sent through the post, but the ability to isolate pathogens decreases as the time between collection of material and receipt by the diagnostic laboratory increases.

There are several diagnostic and taxonomic institutes worldwide that offer a variety of services. For example, CABI Bioscience offers some limited free services for developing countries with the support of the Department for International Development, UK, as well as paid services for commercial interests. The CABI Bioscience Global Plant Clinic is able to diagnose tree health problems and can identify fungi, bacteria, nematodes, viruses and phytoplasmas. The service does not include insect pests unless they are potential vectors of plant pathogens. Other institutes can be located through Web searches or by recommendation from previous contacts.

Collecting and sending samples

Separate guidelines are provided for sending plant material, cultures of fungi or bacteria and insect samples.

The guidelines for sending plant material are as follows.

- Collect fresh material that shows the early stages of symptom development or has evidence of pest infestation (e.g. fungus fruiting bodies)
- Get it to the investigating laboratory as quickly as possible.
- Pack it loosely yet securely to keep humidity low and reduce the chance of mould fungi developing en route. DO NOT PACK IN PLASTIC BAGS!
- Provide information on symptoms and other details of the problem.
- Give each sample a unique code that will allow the receiving laboratory to keep track of your query.

The type of plant material to send depends greatly on the type of tree health problem. A good preliminary diagnosis based on a visual assessment of the symptoms will assist significantly in deciding what sample to send for investigation.

Do not send wilted leaves, for example, since these indicate a systemic disruption or root disease. Dead leaves have limited value in diagnostic investigations. Examine the roots and stems for internal staining and send small portions showing the symptoms. Leaf materials with lesions can be simply pressed by inserting them between sheets of absorbent paper such as newspaper or kitchen roll and then placing them inside a book or under an object to apply light pressure.

Excise the parts of the stems that show symptoms such as cankers or staining at the junction of healthy and stained or decaying tissue. Materials with suspected virus diseases are best preserved before dispatch. Press leaves between absorbent material (best to use filter paper but improvise if necessary) soaked in 50 percent glycerol to help keep leaf material fresh.

Material with suspected phytoplasma diseases can be sent dried or with leaves and young stems preserved in 1 percent borax. Use rigid bottles (preferably plastic) that have a tight seal and do not leak. Reinforce the seal with plastic tape stretched around the container top.

It is vital that all material be carefully and permanently labelled.

The guidelines for sending specimens or cultures of fungi and/or bacteria are as follows.

- Some fungi sporulate on plant structures but others have to be isolated from plant material. Where possible, attempt to do these isolations in situ or at a local laboratory. Simple tap water agar (1.5 percent agar in sterilized tap water) is a useful medium for general purposes.
- Only send the most commonly isolated fungi or bacteria for identification. This reduces the

potential cost of the investigation and increases the chances of getting a quick reply to your query.

- Microfungi should be sent as young, pure cultures. Test tubes, small glass tubes and plastic petri dishes are the simplest containers for sending live fungal material. The safest methods (e.g. freeze-drying) require specialist equipment for preparing cultures.
- Always check cultures for mites. These are best kept in check through sound laboratory techniques.
- Macrofungi (mushrooms, bracket fungi and so on) should be dried and sent in envelopes or paper. DO NOT USE PLASTIC BAGS!

The Plant pathologist's pocketbook (Waller, Lenné and Waller, 2001) provides much useful general information on handling specimens and on growing cultures of fungi.

The guidelines for sending insect specimens are as follows.

- Larvae are difficult to identify; therefore try to rear the insects to adult stage before sending.
- Large insects should be air dried or frozen prior to dispatch and carefully packed in a small tube or vial with tissue paper or cotton to avoid damage.
- Small insects can be preserved in 75 percent alcohol. Place identifying labels (written in pencil or indelible black ink on paper) inside the containers.
- All specimens should be carefully labelled with collector's name, date of collection, site and any host information (species, size, age).
- Keep a carefully labelled reference collecrion of all insects sent for identification for future cross-referencing.

Annex 1

Definitions and explanations related to tree health

Note: For the purposes of this guide the terms used to describe various aspects of tree health have been simplified. Differences from official or published definitions are noted below.

Term	Definition (source*)	Usage in the context of this guide
Abiotic factors	Non living factors such as wind, water, temperature, or soil type or texture (FAO)	
Biotic factors	Living organisms influencing the environment (opposite of abiotic factors) (IPMRC)	Pest organisms that infest trees
Blight	A disease characterized by widespread and rapid killing of plant parts (i.e. leaves, flowers, stems) (FAO)	
Canker	Dead, discoloured, often sunken area on a plant (FAO)	
Condition		General state of well being; see also "tree condition"
Damage	The adverse effect on plants or crops due to biotic or abiotic agents, resulting in a reduction of yield and/or quality (IPMRC)	An injury to a tree, commonly used to describe the effect of insect feeding, but interpreted more generally here
Decline	An interaction of interchangeable, specifically ordered abiotic and biotic factors to produce a gradual general deterioration, often ending in death of trees (IUFRO)	A loss in tree vigour; a gradual and general deterioration in appearance leading to complete death
Diagnosis	Identification of the nature and cause of an illness, ailment of disease on the basis of its signs, symptoms, etiology, pathogenesis, physiopathology, morphopathology etc.; also the decision reached (FAO/IPPC)	The process of finding out the cause of a tree health problem – not only disease
Dieback	Progressive death of shoots, leaves or roots, beginning at the tips (FAO)	
Disease	A condition caused by living organisms or environmental changes that impairs the normal functions of a living organism (FAO)	A harmful deviation of normal plant processes caused by infection with a pathogen
Disorder	Any harmful deviation from normal plant physiological processes due to abiotic factors (IPMRC)	General description of problems caused by non-infectious agents
Epiphytes	A non-parasitic plant that is attached to another plant for mechanical support only; examples include orchids, lichens and mosses (IPMRC)	
Health	The state of well-being; physiological and biochemical processes are undisturbed	See "tree health"
Host	Living organisms that serve as food sources for parasites and parasitoids (FAO)	The tree that harbours a pest organism
Ill health		The adverse effect of pests and other factors on the normal appearance of a tree
Infection	The introduction or entry of a parasite or pathogenic micro-organism into a susceptible host, resulting in the presence of that organism within the body of the host, whether or not this causes detectable pathologic effects (or an overt disease) (IPMRC)	A plant that is infected and shows symptoms is said to be diseased
Infestation	A troublesome invasion of insect pests within a particular area (FAO)	Used more generally to refer to invasion of pest organisms

TERM	DEFINITION (SOURCE[a])	USAGE IN THE CONTEXT OF THIS GUIDE
Injury	Damage of a plant by an animal, physical or chemical agent which impairs plant growth, function and/or appearance but does not necessarily result in loss yield and/or quality (IPMRC)	"Damage" is more commonly used when describing such events in trees
Necrosis	Death of tissue, usually accompanied by black or brown darkening (FAO)	
Nematode	Microscopic cylindrical worms, parasitic on plants or animals or free-living in water (FAO)	
Parasite	An organism that lives on or in a larger organism, feeding upon it (FAO/IPPC)	Parasites do not infect their host and thus do not cause disease; however, plant nematodes are referred to as parasites and pathogens
Pathogen	Micro-organism causing disease (FAO/IPPC)	Includes fungi, bacteria, viruses and phytoplasmas but excludes insects, weeds and other animal pests, e.g. mammals
Pathology	The study of disease (FAO)	
Pest	Any species, strain or biotype of plant, animal or pathogenic agent injurious to plants or plant products (FAO/IPPC)	A primary pest is one that is the leading cause of a problem; a secondary pest contributes to symptoms and damage but is not the principal agent
Saprophyte	Organisms (usually fungus) living on dead or decaying tissue (IPMRC)	Saprobe is the preferred term. Note that fungi are not plants and are distinct organisms
Sign	Evidence of disease as indicated by the presence of the disease-producing organisms or of any of their parts or products e.g. bacterial ooze or fungus structures (IPMRC)	The use of this term in the narrow sense has been avoided in the guide
Stress		A state manifested by a syndrome or bodily changes caused by some force, condition or circumstance, e.g. constraints upon plant growth or survival caused by a harsh environment
Symptom	The apparent changes in an organism as a result of attack, such as by a pathogen or pest (FAO)	Put simply, this is when "something does not look right" Used in a general sense to refer to all visible evidence of ill-health in trees
Syndrome	The totality of effects produced in a host by one disease, whether simultaneously or successively and whether detectable to the unaided eye or not (IPMRC)	
Tree condition		The state of health of a tree
Tree health (individual trees)		"Health of the tree" is the preferred phrase when referring to the state of well-being or normal growth and development individual trees
Tree health (general topic)		The study and consideration of factors that influence the state of well-being and the effects these have on the tree
Vector	Literally "a carrier". An animal carrying a micro-organism pathogenic for members of another species; the vector may or may not be essential for the completion of the life cycle of the pathogenic micro-organism (IPMRC)	

[a] FAO: FAO forest health Web site: www.fao.org/forestry/pests
IPMRC: Integrated Pest Management Resource Centre, *Pest management glossary* : www.ipmrc.com/lib/glossary.shtml
IUFRO: International Union of Forestry Research Organizations, *SilvaVoc*: iufro.boku.ac.at /iufro/silvavoc
FAO/IPPC: FAO/ International Plant Protection Convention , *Glossary of phytosanitary terms* : www.ippc.int/IPP/En

Annex 2

Guide to useful books and sources of information on tree health, insect pests and diseases

Publications are arranged under three general headings:

- General;
- Global;
- Regional or country emphasis.

General

This selection of books will help the reader learn more about pests and the more technical and scientific aspects of tree health. Some specifically emphasize forestry while others concentrate on insect pests and diseases of crop plants. The emphasis on a particular pest group is of less importance, when it comes to understanding biology, ecology, infection processes of pathogens and feeding habits of insects.

CABI crop protection compendium: global module. 2001. Wallingford, UK, CABI Publishing.

The most comprehensive and up-to-date source of information on all groups of plant pests. Copiously illustrated and contains photos that can be cut and pasted to create data sheets. Few forestry species are included; the equivalent forestry compendium has information on tree pests but is principally a silvicultural guide. The *CABI crop protection compendium* is an excellent and affordable guide to symptoms and features of pest attack on plants.

AVAILABILITY: www.cabicompendium.org

Field and laboratory guide to tree pathology. R.O. Blanchard & T.A. Tattar. 1997. New York, USA, Academic Press.

A standard guide to laboratory and field methods and procedures. Mainly concerned with fungal diseases although other non-insect pests are included.

AVAILABILITY: www.academicpress.com

Foliar symptoms of the nutrient disorders in the tropical shrub legume Gliricidia sepium. F.W. Smith & P.J. Vanden Berg 1992. Division of Tropical Crops and Pastures Technical Paper No. 30. Indooroopilly, Queensland, Australia, CSIRO Publishing.

Well illustrated, in colour. One of a series of three books that describes the effect of nutrient imbalances in important woody legumes based on experimental work in Australia; the other two books are on nutrient disorders in *Leucaena* and *Calliandra* species.

AVAILABILITY: www.publish.csiro.au

Forest health: its assessment and status. J. Innes. 1995. Wallingford, UK, CAB International.

The standard text addressing all factors, including tree pests, that affect the condition and overall health of trees. It is both a scientific account of tree health studies from Europe, North America and other countries, and a practical guide. Selected problems are illustrated with black and white photos.

AVAILABILITY: www.cabi.-publishing.org

Insect pests in tropical forestry. M.R. Speight & F.R. Wylie. 2000. Wallingford, UK, CAB International Publishing.

An excellent introduction that includes fundamental scientific aspects and practical control measures against tree pests. Pest damage is well described and there are colour photographs of insect pests infesting (mostly) plantation tree species, although agroforestry species are also included.

AVAILABILITY: www.cabi-publishing.org

Nutrient disorders in plantation eucalypts. B. Dell, N. Malajczuk & T.S. Grove. 1995. ACIAR Monograph 31.

Well illustrated and in colour. A comprehensive guide based on work in Australia but of global relevance and application. A good source of general information that could be applied, albeit with caution, to other tree species.

AVAILABILITY: www.aciar.org

Plant pathology. G. Agrios. 1997. San Diego, California, USA, Academic Press.

A popular and much-used undergraduate text that provides a general introduction to all pest groups except insects. Includes some examples of forest diseases although predominantly concerned with crop plants.

AVAILABILITY: www.academicpress.com

Plant pathologist's pocketbook. 3rd edition. J.M. Waller, J.M. Lenné & S.J. Waller. 2001. Wallingford, UK, CABI Publishing.

A practical guide to laboratory and field practice. Contains advice on collecting samples, survey techniques and photography. Emphasis is on crop plants, but some information on trees.

AVAILABILITY: www.cabi-publishing.org

Principles of forest pathology. F.H. Tainter & F.A. Baker. 1996. New York, USA, John Wiley & Sons.

Describes scientific aspects of tree pathogens based on examples and experiences in North America.

AVAILABILITY: www.wiley.com.

Global

Compendium of conifer diseases. E. Hansen & K.J. Lewis. 1997. St. Paul, Minnesota, USA, APS Press.

Main examples are taken from North America and Europe but also information on major conifers from other continents and information on disorders. All problems are illustrated by colour photographs, but are often too small to be practical. Good source of up-to-date knowledge on major disease problems.

AVAILABILITY: www.shopapspresss.org

Decline and dieback of trees and forests. W.M. Ciesla & E. Donaubauer. 1994. FAO Forestry Paper 120. Rome.

A good introduction to abiotic diseases with a global overview; most examples are taken from Europe and North America. The photographs are in black and white and describe selected problems.

AVAILABILITY: www.fao.org

Diseases and pathogens of eucalypts. P.J. Keane, G.A. Kile, F.D. Podger & B.N. Brown. 2000. Indooroopilly, Queensland, Australia, CSIRO Publishing.

A comprehensive scientific account from Australia; also includes information from other countries and their diseases. A reference book rather than a practical guide. Contains many colour photographs but their use for diagnostic purposes is limited.

AVAILABILITY: www.publish.csiro.au

Regional or country emphasis

ASIA

Manual of diseases of tropical acacias in Australia, South-East Asia and India. K. Old, S.S. Lee, J. Sharma & Q.Y. Zi.. 2000. Bogor, Indonesia, CIFOR.

First major account of tree pest problems reported from India to Australia where acacias have been widely planted for nascent forest plantation industries. The clear and helpful photographs of symptoms and pests will help in diagnosing problems.

AVAILABILITY: www.cifor.org

EUROPE [UK]

Diagnosis of ill health in trees. R.G. Strouts, R.G. & T. Winter. 2000. London, UK, The Stationary Office.

An excellent book, practical with well-chosen and organized colour photos. Information comes from many different starting points: host tree, pest name, symptom or type of damage. Much effort has been expended in providing a clear layout, as well as succinct and informative text.

AVAILABILITY: www.the-stationary-office.co.uk

EUROPE

Tree diseases and disorders: causes, biology and control in forest and amenity trees. H. Butin. Edited by D. Lonsdale. Oxford, UK, Oxford University Press.

General text with an emphasis on Europe. Also describes individual diseases and disorders (non-pest problems) on a selected range of tree species.

AVAILABILITY: www.the-stationary-office.co.uk

NORTH AMERICA

Diseases of trees and shrubs. W.A. Sinclair, H.H. Lyon & W. Johnson. 1989. Ithaca, NY, USA, Cornell University Press.

A large format book with the most comprehensive collection of good and well-reproduced photographs. Although the selection of tree species is geared towards all aspects of forestry in North America, this book has wider applications in recognizing and interpreting symptoms. It is difficult to examine lists of diseases on individual tree species because of how this information is condensed and displayed in the index. However, the accounts of different diseases are arranged mostly by pest, and are clear and informative.

AVAILABILITY: www.cornellpress.cornell.edu

NORTH AMERICA

Insects that feed on trees and shrubs. 2nd edition. W.T. Johnson & H.H. Lyon. 1991. Ithaca, NY, USA, Cornell University Press.

An impressive and widely useful book that predated the companion volume, Diseases of trees and shrubs (see above). A separate index for insects, mites and other animals makes it easier to locate information.

AVAILABILITY: www.cornellpress.cornell.edu

USA

Insects and diseases of trees in the South. Protection Report R8-PR16. United States Department of Agriculture - Forest Service, Southern Region.

Includes both insect pests and diseases of commercial forestry species.

AVAILABILITY: www.fhpr8.srs.fs.fed.us/idotis/insects.html

Annex 3

Tree hosts and health problems illustrated in the colour plates

Host, country	Plate	Description
Acacia auriculiformis, Indonesia	15.14	Exudation of fluid, "bleeding"
Acacia koaia, Hawaii	4.5	Rust, witches' broom
Acacia mangium, Indonesia	2.2	Rust galls
Acacia mangium, Indonesia	7.4	Root disease
Acacia mangium, Indonesia	7.6	Leaf scorch, herbicide damage
Acacia mangium, Indonesia	12.5	Root rot
Acacia mangium, Indonesia	13.11	Squirrel damage
Acacia mangium, Indonesia	15.9	Twisted root
Acacia mangium, Indonesia	15.10	Bad pruning
Acacia sp., Indonesia	14.15	Pink disease (fungus)
Acacia sp., Indonesia	11.8	Canker
Acacia sp., India	15.6	Human damage
Acacia xanthophloea, South Africa	15.3	Cutting damage
Acer pseudoplatanus, France	12.2	Ganoderma rot (fungus)
Acer pseudoplatanus, UK	13.13	Squirrel feeding
Alnus glutinosa, UK	6.2	Phytophthora root disease (fungus)
Aphanomixis polystachia, Bangladesh	4.7	Phytoplasma infection
Araucaria araucana, Chile	14.1	Seed fungus
Araucaria araucana, Chile	16.4	Lichens
Arundinaria alpina, Ethiopia	7.2	Dying bamboo because of flowering
Austrocedrus chilensis, Argentina	1.3	Decline, possibly fungal root disease
Austrocedrus chilensis, Argentina	12.6	Decline, possibly fungal root disease
Azadirachta indica, Niger	1.1	Possibly genetic abnormality
Azadirachta indica, Nigeria	5.4	Neem decline
Azadirachta indica, Nigeria	6.1	Neem decline
Azadirachta indica, Nigeria	7.5	Insect scale
Azadirachta indica, Nigeria	8.4	Bird damage
Azadirachta indica, India	9.3	Wilting, tea mosquito
Azadirachta indica), Nigeria	15.2	Liquid exudation
Azanza garkeana, Botswana	4.6	Suspected phytoplasma disease
Bambusa vulgaris, Bangladesh	7.1	Bamboo blight
Betula pendula, UK	7.8	Mammal feeding
Brachystegia sp., Malawi	14.8	Termite bark feeding
Buddleja sp., Bolivia	14.6	Powdery mildew

HOST, COUNTRY	PHOTO	DESCRIPTION
Calliandra calothyrsus, Honduras	2.6	Swelling due to fungus (*Nectria*)
Calophyllum inophyllum, Seychelles	9.3	Takamaka wilt
Casuarina equisetifolia, China	6.5	Bacterial wilt
Casuarina equisetifolia, India	11.10	Blister bark disease
Casuarina equisetifolia, Senegal	12.4	Root rot
Catalpa bignonioides, Germany	8.3	Dieback
Celtis africana, South Africa	1.4	Waterlogging
Citrus, Bolivia	14.3	Scale insects
Citrus, Bolivia	14.5	Velvet mould (fungus)
Cocos nucifera, USA	9.4	Lethal yellowing (phytoplasma
Cupressus lusitanica, South Africa	11.7	Fungal canker (*Seiridium*)
Dalbergia sissoo, Bangladesh	9.1	Wilt
Dalbergia sissoo, Bangladesh	9.2	Wilt
Delonix regia, Saipan island, Marianas	14.7	Fungus mat (*Phellinus*)
Dillenia sp., Indonesia	13.10	Insect damage
Erythrina falcata, Bolivia	5.1	Stunting
Eucalyptus sp., Brazil	1.11	Fungal canker
Eucalyptus sp., Mexico	9.5	Bacterial ooze
Eucalyptus sp., Mexico	9.6	Bacterial wilt
Eucalyptus sp., Thailand	10.1	Leaf spot
Eucalyptus sp., South Africa	11.1	Fungal canker
Eucalyptus sp., Brazil	11.4	Fungal canker
Eucalyptus sp., South Africa	11.5	Fungal canker
Eucalyptus sp., country unknown	11.12	Gummosis
Eucalyptus sp., country unknown	11.13	Liquid exudate
Eucalyptus sp., South Africa	12.1	Pythium root rot (fungus)
Eucalyptus sp., Brazil	14.4	Fungus mat
Eucalyptus urophylla, Brazil	10.5	Fungal leaf lesion
Ficus sycomorus, Malawi	10.8	Insect galls
Fraxinus uhdei, Colombia	15.12	Pruning
Fraxinus uhdei, Colombia	4.1	Phytoplasma, ash yellows
Fraxinus uhdei, Colombia	15.13	Bad pruning
Fraxinus excelsior, UK	8.5	Dieback
Fraxinus excelsior, UK	10.6	Bacterial canker
Fraxinus excelsior, UK	11.2	Fungal canker
Fraxinus excelsior, UK	11.3	Bacterial canker ("knots")
Gliricidia sepium, Guatemala	3.1	Shoestring virus
Gliricidia sepium, Honduras	4.3	Little leaf disease, phytoplasma

HOST, COUNTRY	PLATE	DESCRIPTION
Gliricidia sepium, Honduras	5.3	Little leaf disease, phytoplasma
Gliricidia sepium, Guatemala	8.1	Little leaf disease, phytoplasma
Gliricidia sepium, Guatemala	8.2	Little leaf disease, phytoplasma
Gliricidia sepium, Honduras	10.9	Discolouration of leaves, virus
Gmelina arborea, Indonesia	13.3	Beehole borer, internal feeding
Gmelina arborea, Indonesia	13.4	Beehole borer, internal feeding
Gmelina arborea , Indonesia	13.12	Deer damage
Gmelina arborea, Indonesia	14.14	Termite feeding in roots
Grevillea robusta, India	15.4	Pruning damage
Guadua angustifolia, Colombia	6.3	Premature death
Guadua angustifolia, Colombia	12.7	Culm decay
Guadua angustifolia, Colombia	16.5	Lichens
Hevea brasiliensis, Indonesia	11.11	Phellinus canker (fungus)
Inga cylindrica, Bolivia	14.11	Rust
Inga edulis, Bolivia	2.7	Agrobacterium galls
Leucaena leucocephala, Nepal	13.1	Psyllid infestation
Litchi chinensis, Viet Nam	14.12	Gall mite
Melia azedarach, Bolivia	1.9	Phytoplasma, yellows
Melia azedarach, Bolivia	5.5	Phytoplasma, yellows
Melia azedarach, Bolivia	5.6	Phytoplasma, yellows
Melia azedarach, Bangladesh	10.3	Cercospora leaf spot (fungus)
Metrosideros polymorpha, Hawaii	12.8	Armillaria root rot (fungus)
Mimosa schomburgkii, Brazil	2.3	Rust fungus on stem
Miombo tree, Malawi	16.3	Lichens
Nothofagus sp., New Zealand	8.7	Ganoderma root disease (fungus)
Olea europea, Spain	2.8	Bacterial knots
Paraserianthes falcataria, Indonesia	13.5	*Phoracantha* insect feeding
Paraserianthes falcat aria, Indonesia	14.9	Termite nest
Paraserianthes falcataria, Seychelles	15.8	Ring barking
Paraserianthes falcataria, Indonesia	16.6	Lichens
Pinus merkusii, Indonesia	15.5	Tapping for resin
Pinus caribaea var. *hondurensis*, Venezuela	12.3	Bluestain
Pinus elliottii, USA	2.5	Rust on cones
Pinus patula, Venezuela	1.6	Drought, poor planting
Pinus patula, Colombia	1.8	Boron deficiency
Pinus radiata, Ecuador	10.4	Dothistroma blight (fungus)
Pinus radiata , New Zealand	15.7	Frost damage
Pinus sp., Bolivia	1.7	Drought damage

HOST, COUNTRY	PLATE	DESCRIPTION
Pinus sp., Brazil	2.4	Healing of canker
Pinus sp., Bolivia	4.2	Foxtailing
Pinus taeda, Hawaii	7.7	Fungus
Polylepis incana, Bolivia	5.2	Stunting
Polylepis incana, Bolivia	10.2	Fungus leaf spot
Populus sp., USA	11.9	Hypoxylon canker (fungus)
Populus sp. ("columnaris"), Bolivia	14.10	Rust
Prunus persica, Bolivia	1.2	Phytoplasma, peach yellows
Prunus persica, Bolivia	3.5	Aphid damage
Prunus persica, Bolivia	3.6	Leaf curl
Prunus persica, Bolivia	13.8	Aphid and sooty mould (fungus)
Prunus persica, Bolivia	15.1	Hail damage
Pterocarpus indicus, Seychelles	13.2	Borer tunnels
Pterocarpus indicus, Seychelles	13.6	Leaf miner
Pterocarpus indicus, Seychelles	15.11	Normal sap bleeding
Quercus velutina, USA	1.5	Leaf scorch, bacterial
Schinus molle, Bolivia	3.4	Psyllid damage
Schinus molle, Bolivia	14.13	Parasitic plant
Schinus molle, Bolivia	14.16	Insect larvae on trunk
Sclerocarya birrea, Botswana	3.3	Stubby shoots
Sterculia quinqueloba, Malawi	8.6	Dieback
Syzygium aromaticum, Indonesia	6.4	Bacterial wilt
Tabebuia serratifolia, Brazil	10.7	Leaf lesions, fungal
Theobroma cacao, Peru	7.3	Web blight
Theobroma cacao, Ecuador	16.1	Epiphytic plant
Toona ciliata, Malawi	1.10	Changes due to dry season
Uapaca kirkiana, Malawi	3.2	Leaf curl
Uapaca kirkiana, Malawi	11.6	Canker or knot
Uapaca kirkiana, Malawi	13.7	Insect feeding (skeletonizer)
Unknown tree, Bolivia	4.4	Chewing foliage
Unknown tree, Seychelles	13.9	Feeding marks of insects
Unknown shrub, Bolivia	14.2	Aphids
Vangueria infausta, Botswana	2.1	Mite induced galls

Insect pests and diseases routinely affect the health of trees, and major outbreaks can have catastrophic environmental and economic impacts. The effective management of all tree health problems depends on their early detection. This guide will help readers recognize symptoms of ill health in trees and understand their general significance. The guide provides 140 photographs of symptoms from more than 50 tree species to be used as a basis for demonstrating the effects of pest (biotic) and non-living (abiotic) influences on trees. It is not an identification guide to insect pests and diseases of trees, but aims to help people make visual assessments of tree health problems and to provide a preliminary diagnosis which in turn will assist in better planning and more effective management of forests and trees. The guide will be useful to anyone interested in tree health or responsible for managing trees.

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